CHAPTER IV

METHODOLOGY

- Method Adopted.
- Tools Used for the Study.
- Sample of the study.
- The Experiment Conducted.
- Statistical Methods adopted.
CHAPTER IV

METHODOLOGY

The study is formulated to best suit the nature of the problem under investigation, objectives of the study, resources available, characteristics of the population and expected precision and quality. The objective of the present study is to estimate the effectiveness of Concept Attainment Model of instruction on achievement in mathematics of academically disadvantaged students at secondary level. Accordingly, the eighth standard students in the schools of Kerala following State syllabus were the target population of the study. The details of the methodology adopted for the study are presented in the following subheadings.

4.1 Method Adopted.

Experimental method was adopted for the present study. Experimental research is the most conclusive of scientific methods. It is the only type of research that directly attempts to influence a particular variable, and can really test hypothesis about cause-and-effect relationships. An experiment usually consists of two groups of subjects - an experimental group and a control group or comparison group, although it is possible to conduct an experiment with only one group or with three or more groups.
4.1.1 Research Design.

In this study, Non-equivalent pretest-posttest control group design was used. The most common reason that experimental design cannot be employed is the randomisation of subjects to experimental and control groups is impossible and that a control or comparison group is unavailable, inconvenient or too expensive. Quasi-experimental designs can be used effectively in these circumstances. These designs provide reasonable control over the most sources of invalidity and they are usually stronger than the pre-experimental designs.

4.1.1.1 Non-Equivalent Pretest - Posttest Control Group Design

This design is very prevalent and useful in education, since it is often practically difficult to randomise subjects. The researcher in such occasions uses intact, already established groups of subjects, gives a pretest, administers the treatment condition to one group and then gives the posttest. The design can be represented by the figure 4.1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre test</th>
<th>Treatment</th>
<th>Post test</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 4.1 Non-Equivalent Pretest - Posttest Control Group Design  
(McMillan and Schumacher, 1989)
4.1.1.2 Stages of the Study.

The study was carried out in three stages. The first stage was the pretest stage; in which the learners were tested on intelligence, socio-economic status, achievement in the selected topics, mathematical attitude, self concept, home learning environment, cognitive ability, achievement motivation, mathematics interest, and study habits.

The second stage was the conduct of experiment. The experimental treatment, i.e. teaching through Concept Attainment Model was given to one group (Experimental Group) of students. The other group (Control Group) of students was taught through conventional teaching method.

The third stage was the posttest stage. In this the learners were tested on achievement in the specified content and cognitive ability.

The detailed design of the study is presented in the figure 4.2.

4.1.2 Variables of Study

Variables are the conditions or characteristics that the experimenter manipulates, controls or desires. The present study involved independent and dependent variables.

4.1.2.1 Independent Variable

In experimentation, the manipulated variable is called as independent variable. "It is under the direct control of the experimenter who may vary it in any direction" (Sax, 1979). "In experimental studies the condition that is varied
is referred to as the independent variable. If the effect of teaching strategy is measured by means of an achievement test, then the score on the test is referred to as the dependent variable" (Travers, 1964). The present study measures the effectiveness of Concept Attainment Model with conventional teaching method. Therefore the independent variables (experimental variables) are the Concept Attainment Model of instruction and conventional teaching method.

4.1.2.2 Dependent Variable.

The dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes
independent variable (Best, 1983). Here student performance (achievement) is the dependent variable. There is a chance of many variables that affect/influence the dependent variable. Achievement in mathematics of students can be affected by their intelligence, socio-economic status, home learning environment, interest in mathematics, cognitive ability, achievement motivation, mathematics attitude etc. But for the present study, the difference in achievement that would have been caused by these variables was made minimum by adopting the statistical technique ANCOVA.

4.2 **Tools Used for the Study.**

The tools used in the present study were:

1. Lesson transcripts based on Concept Attainment Model of instruction (Developed by the Investigator).
2. Achievement test in Mathematics (Developed by the Investigator).
3. Cognitive Ability Test (Developed by the Investigator).
4. Lesson Plans based on Conventional Teaching Method
5. Rao Achievement Motivation Test.
7. Self-concept Inventory by Dr R.K. Saraswat.
8. Study Habits Inventory by B.V Patel.
9. Mathematics Interest Inventory.
10. Mathematics Attitude Scale by H.G. Desai.
11. Home Learning Environment Inventory (Revised).
12. Raven's Progressive Matrices Set: A, B, C, D and E.

4.2.1 Lesson Transcripts based on Concept Attainment Model of instruction.

Lesson transcripts based on Concept Attainment Model in mathematics for the topics “Sets” and “Expansion of algebraic Expressions using Identities” and “Simple Equations” were prepared by the investigator to cover the concepts in the topics in the prescribed mathematics curriculum of 8th standard in Kerala following the State syllabus.

(i). Construction of Lesson Plans

The topics under consideration were analysed and relevant concepts were identified and listed in the sequential order of development of the content.

Instructional Models of Concept Attainment are based on early studies by Bruner, et al. (1967) describing the process by which pupil discriminates essential features of events or things, and groups them into cohesive categories.

In the model outlined by Weil and Joyce (1978), new concepts are taught by presenting sequences of examples and non-examples, and generating hypotheses about what the concept is. In this receptive process, the teacher presents information initially, but later retreats and encourages students to reflect on the responses they generate on their own.

Tennyson and Park (1980) reviewed research in the area of “Reformation of Concept Attainment Model” and pointed out the importance of inclusion of a response-sensitive approach to instruction. If students are having confusing
concepts or are having trouble in acquiring abstract concepts, the instructor's charge is to adapt the presentation of information accordingly. Another variation they emphasised is the importance of surrounding structure of a concept. Hierarchical network of concept can be used to instrumental advantage—as a way of tying down new concepts to things students already know, and as a way of providing transfer from knowledge about concepts in one category to knowledge about concepts in other categories.

The Tennyson–Park Empirically based Model of Instruction consists of 4 steps. In the first stage the instructor analyses the conceptual network involved and determines the network location of the particular concept to be taught. In this stage critical and variable attributes of a concept are to be determined. The second stage is the presentation of definition of a concept, its examples and non-examples. In the third stage the instructor and students engage in a matching exercise whereby they determine which examples in the pool are actually examples of the concept using the criteria of critical and variable attributes (non-examples should vary on critical attributes, examples should vary on variable attributes). Finally the instructor presents a new set of examples according to students' increased level of knowledge about concept. This model was found effective in attainment of concepts in different subjects. Its purported adaptivity to learner individual differences has been documented.

In this study, the lessons on concept Attainment Model was prepared based on the light of recommendations made by Tennyson and Park (1980).
The topics namely “Sets”, “Expansion of algebraic Expressions using Identities”, and “Simple Equations” in the 8th standard Mathematics Textbook of Kerala State syllabus were analysed and 32 concepts were selected for the study.

The concepts selected from the topic “Sets” were as follows.

(i) Sets
(ii) Elements of a set
(iii) Cardinality of a set
(iv) Finite set
(v) Infinite set
(vi) Singleton set
(vii) Doubleton set
(viii) Null set
(ix) Subset
(x) Superset
(xi) Proper subset
(xii) Equivalent sets
(xiii) Identical sets
(xiv) Union of sets
(xv) Intersection of sets
(xvi) Disjoint sets
(xvii) Complement of a set
(xviii) Difference of two sets
The concepts selected from the topic “Expansion of Algebraic Expressions using Identities” were listed below.

(i) Phrase
(ii) Sentence
(iii) Algebraic phrase
(iv) Numerical phrase
(v) Numerical sentence
(vi) Algebraic sentence
(vii) Closed sentence
(viii) Open sentence
(ix) Always true sentence
(x) Identity
(xi) Domain
(xii) Truth set

The concepts selected from the chapter “Simple Equations” were as follows.

(i) Simple Equations
(ii) Equivalent equations

Thus altogether 32 concepts from these three topics were selected for the experiment.

In effective teaching of a concept, a thorough analysis of that concept is essential. Concept analysis is a planning tool, which is valuable in structuring of concept learning activities. It is a thorough examination of different aspects of concepts. It involves descriptions of the following.
1. **Concept Analysis.**

   **a) Concept Name**

   The concept name is the label attached to the mental construct, and that name is used for further communication.

   **b) Concept Definition**

   A concept definition is a statement that summarises the description of the concept and helps a learner achieve a form of closure related to it.

   The role of examples and definitions in learning concepts is well documented. Tennyson (1978) and Feldman (1980) found in studies of college students and sixth grades respectively that examples combined with definitions resulted in greater learning than either alone.

   **c) Characteristics.**

   The common features that describe a concept are called the concept’s characteristics or attributes. The ease or difficulty of learning a concept depends upon the number of characteristics a concept has and how tangible or concrete those characteristics are (Stanley & Mathews, 1985; Tennyson & Cocchiarella, 1986).

   **d) Examples and Non-examples.**

   Concept is learned through generalising from the common features in an observed class. The learner is exposed to examples and non-examples of the concept, identifies the features common to the examples that are not found in the non-examples and generalises from these features.
e) **Superordinate Concept.**

Each concept is formed in relation to the other concepts. Superordinate concept is a larger set into which the concept fits. For example superordinate concept of trapezoid is quadrilateral.

f) **Subordinate concept.**

Subordinate concept is a smaller set, which fits in the concept. For example the subordinate concept of parallelogram is rhombus or square. Subordinate concepts help to frame examples.

g) **Coordinate Concept.**

The concept, which has a coordinate relationship with the referred concept within a frame of reference, is called a coordinate concept. Coordinate concept helps to frame non-examples. To frame a coordinate concept of a particular concept, first list the characteristics of the concept. Then frame concepts based on these dimensions. For example, consider the concept ‘cat’. One characteristic of cat is ‘mammal’. Then a coordinate concept of ‘cat’ is ‘horse’ or ‘cow’. A coordinate concept of ‘parallelogram’ is ‘trapezoid’.

2. **Preparation of Content Goals.**

The Concept Attainment Model focuses to concept learning. The content goals for a Concept Attainment Model lesson can be planned according to the developmental level of children and demand of the particular situation. The thinking processes are more demanding in the Concept Attainment Activity because students are asked to hypothesise a label for the concept.
The implementation phases of Concept Attainment Model is very flexible and fun for both the instructor and the students because the process can be presented as a type of game which, combined with its inherent sense of the unknown, results in increased student motivation.

3. Phases of Concept Attainment Model of Instruction.

a) Phase 1: Establishment of a Relaxed Atmosphere.

Pupil must feel free to express ideas without fear of ridicule or failure. Therefore teachers should do their best to convince the students that they are free to play with ideas. Regardless of how silly some contribution may seem, teacher should avoid ridiculing those who makes them. If one or more students laugh when a classmate says something, the teacher should do her best to gloss over the incident by noting that the idea is worth.

b) Phase 2: Analysis of Conceptual Network Involved.

Concepts exist in context, as part of larger network of concepts. There are superordinate concepts and coordinate concepts. Effective learning of a concept can be made easy, when the knowledge of the concept can be tied with its superordinate and subordinate concepts. The teacher asks the students to discuss their experiences and familiar concepts relating to the concept under consideration. Here a process of tying down the familiar concepts relating to the concept to be taught is being done.

When teacher makes students understand that concepts exist in networks, they will establish or extend such networking as they learn new concepts. In this
phase the related concepts of the concept, which is going to deal with, be discussed and pupil's knowledge relating to it can be tested.

c) **Phase 3: Providing Examples and Non-Examples.**

Teacher presents the students a list of examples and non-examples of the concept under consideration. Typically it starts with an example and a non-example presented together and identified as such. The words 'yes' or 'no' 'plus' and 'minus' symbols etc have been used for indicating whether the example is positive or negative.

d) **Phase 4: Response-Sensitive Discussion.**

In this phase the teacher asks the students to hypothesise possible categories that would encompass the examples. This phase is called response-sensitive because the discussion will change depending on the student response. The teacher makes the students to compare the attributes described in positive and negative examples. Students generate and test the hypothesis. At the end of discussion the students may be able to state a definition according to the essential attributes. During the analysis of hypothesis the teacher refrain from passing judgements. By doing so, the teacher makes the concept attainment activity a guessing game.

Thus the teacher should place the responsibility for identifying and verifying the concept at the student. Through the process of analysis and making inferences, students become more proficient in these thinking skills and also more autonomous learners.
e) Phase 5: Providing more Examples and Non-Examples.

In this phase teacher presents additional positive and negative examples and students analyse and verify hypothesis and eliminate those not supported by the data.

f) Phase 6: Students Generate Examples.

In the light of above process the students generate examples for the prescribed concept.

g) Phase 7: Defining the Concept

By analysing the hypothesis in the light of examples and non-examples, students state a definition according to the essential attributes. Teacher confirms the hypothesis, names the concept and restates the definition according to the essential attributes.

h) Phase 8: Assessing the Attainment of Concept.

In this phase, the teacher evaluates the level of concept attainment of the students. It is tested by presenting unlabelled examples. Students label them as positive or negative examples based on the essential attributes discussed in the 7th phase.

i) Phase 9: Analysis of Thinking Strategy Involved.

In this, students begin to analyse the strategies by which they attain concepts. Some students initially try broad constructs and gradually narrow the field and some begin with more discrete constructs. The learners can describe
their patterns of thinking. Finally they can compare the effectiveness of several strategies.

The age, cognitive structure and previous knowledge of the students were also taken into consideration while preparing these lesson plans. Sample classes were taken and schoolteachers observed the teaching-learning activities and sufficient modifications have been done taking into account the suggestions put forward by them. Sample lesson format is given in the figure 4.3. Sample lessons are given in the Appendix A.

4.2.2. Achievement Test in Mathematics.

Achievement Test can be defined as a test designed to measure the effects of specific teaching or training in an area of curriculum. The concepts selected for the study were included from the topics Sets, Expansion of Algebraic Expressions using Identities and Simple Equations from the VIIIth standard mathematics syllabus (Kerala State syllabus). Since no specific achievement test in the topics selected was available, to test the effectiveness of experimental teaching strategy on students' performance in mathematics, an achievement test on the concepts from the above topics was prepared by the investigator. The planning of the achievement test is described below.

1. The planning for an Achievement Test.

Good testing needs adequate, thorough and extensive planning. Planning depends upon two fundamental issues: first 'what is to be tested' and
### Lesson Format of Concept Attainment Model of Instruction

<table>
<thead>
<tr>
<th>Subject</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit</strong></td>
<td></td>
</tr>
<tr>
<td>Concept Analysis</td>
<td></td>
</tr>
<tr>
<td>Concept Name</td>
<td></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td></td>
</tr>
<tr>
<td>Attributes</td>
<td></td>
</tr>
<tr>
<td><strong>Superordinate Concept</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Subordinate Concept</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Coordinate Concept</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td></td>
</tr>
<tr>
<td>Positive Examples</td>
<td></td>
</tr>
<tr>
<td>Negative Examples</td>
<td></td>
</tr>
<tr>
<td><strong>Content Goals</strong></td>
<td></td>
</tr>
<tr>
<td>(To attain the above concept and to develop students' cognitive ability skills)</td>
<td></td>
</tr>
<tr>
<td><strong>Materials Required</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phases/Stages</strong></td>
<td></td>
</tr>
<tr>
<td>Phase I</td>
<td>Establishment of a Relaxed Atmosphere</td>
</tr>
<tr>
<td>Phase II</td>
<td>Analysis of Conceptual Network Involved</td>
</tr>
<tr>
<td>Phase III</td>
<td>Providing Examples and Non-Examples</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Response-Sensitive Discussion</td>
</tr>
<tr>
<td>Phase V</td>
<td>Providing more Examples and Non-Examples</td>
</tr>
<tr>
<td>Phase VI</td>
<td>Students Generate Examples</td>
</tr>
<tr>
<td>Phase VII</td>
<td>Defining the Concept</td>
</tr>
<tr>
<td>Phase VIII</td>
<td>Assessing the Attainment of Concept</td>
</tr>
<tr>
<td>Phase IX</td>
<td>Analysis of Thinking Strategy Involved</td>
</tr>
</tbody>
</table>

*Figure 4.3 Lesson Format for CAM*
second ‘how to test’. The first issue deals with purpose- objective and content of the test, while the second issue is concerned with procedure.

a). The Purpose of Test.

Achievement tests serve a variety of functions. In this study an achievement test was constructed: 1) to judge the pupils accomplishment in certain concepts, 2) to grade pupils in terms of their achievement, 3) to evaluate the instructional strategies- concept attainment model and traditional method, 4) using the achievement test as pretest and posttest to assess the entry behaviour and criterion behaviour of students.

b). Specification of Course Content.

The second important step followed was to specify course content. According to prescribed syllabus of mathematics for standard VIII (Kerala State Syllabus) the topics “Sets”, “Expansion of Algebraic Expressions Using Identities” and “Simple Equations” were tested. The concepts selected from the chapter “Sets” were as follows.

Sets
Elements of a set
Cardinality of a set
Finite set
Infinite set
Singleton set
Doubleton set
Null set
Subset
Superset
Proper subset
Identical sets
Equivalent sets
Union of sets
Intersection of sets
Difference of two sets
Complement of a set
Disjoint sets
The concepts selected from the chapter “Expansion of Algebraic Expressions using Identities” are listed below.
Phrase
Sentence
Algebraic phrase
Numerical phrase
Numerical sentence
Algebraic sentence
Closed sentence
Open sentence
Always true sentence
Identity
Domain
Truth set
The concepts selected from the chapter “Simple Equations” are as follows.
Simple Equations
Equivalent Equations
The prepared achievement test consisted of two parts; Part I was for the concepts from the topic Sets and part II was for the concepts from the topics
Expansion of Algebraic Expressions using Identities and Simple Equations. This was used as pretest and posttest.

Weightage given to different concepts in the achievement test were as follows.

Table: 4.1

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Concepts</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sets</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Elements of a set</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Cardinality of a set</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Finite set</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Infinite set</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Singleton set</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Doubleton set</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Null set</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Subset</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Superset</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Proper subset</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>Identical sets</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Equivalent sets</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>Union of sets</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>Intersection of sets</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>Difference of two sets</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>Complement of a set</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>Disjoint sets</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>


Table: 4.2

Weightage Given to Different Concepts for Part II in the Achievement Test

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Concepts</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Phrase</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Sentence</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Algebraic phrase</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Numerical phrase</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Numerical sentence</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Algebraic sentence</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Closed sentence</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Open sentence</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Always true sentence</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Identity</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Domain</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Truth set</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Simple Equations</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>Equivalent Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

c). **Deciding the Instructional Objectives.**

After deciding the content, the objectives to be tested were decided. The following objectives in the cognitive domain were set for teaching: 1) knowledge, 2) comprehension, 3) application, and 4) analysis. Hence these objectives were selected for testing.

The weightage to different objectives in the test are given below.
Table 4.3.

**Weightage to Objectives for Part I of the Achievement Test**

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Objectives</th>
<th>Marks</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Analysis</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.4

**Weightage to Objectives for Part II of the Achievement Test**

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Objectives</th>
<th>Marks</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Analysis</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

2. **Preparation of the Blueprint.**

To ensure that the test adequately covered the content, the investigator has satisfied the most important criterion of the test – 'the content validity'. Therefore a blue print was prepared and discussed with experts. As regards weightage, Mehran and Lehmann (1973) clearly stated that "there is no hard and fast rule that can be prescribed for the teacher to use in determining the weightage to be assigned to various cells in the blue print. Experience is his best source".
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The blueprint is a three-dimensional chart containing coverage of content, objectives and type of questions. The cell in the blueprint represents the number of items to be included in the test in relation to any particular objective. The blueprints of the two parts of the test are given in Table 4.8 and Table 4.9. More than required number of items was included in the test under each objective and content sub-units. This was done so as to get enough items for the final test. After deciding 'what is to be tested?' the next issue was 'how to test?' This was answered through the following steps.

3. Selection of Item Format.

The investigator selected the format of objective type items, because the purpose was to test the pupils' conceptual knowledge, their understanding of the concepts as an ability to apply and interpret. While preparing the objective type items, the following general rules were followed.

(1). Ask questions as simple and concisely as possible to help ensure valid and reliable test results.
(2). Ask students to apply, rather than simply to recall information.
(3). Make sure that each item is independent i.e. one question does not provide a clue to some other question
(4). Do not establish or follow a pattern for correct response.
(5). Do not include trick or trivial question. Trick or trivial questions reduces the validity and reliability of tests.

Thus keeping all the plus points of objective type items, it was decided to prepare a test with objective type items. Of the different objective type items, the
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investigator decided to prepare multiple choice items, because they can be used easily to sample cognitive skills ranging from simple recall through analysis.

While preparing the multiple-choice items, the following principles were followed.

(1). Put as much of the item as possible into the stem.

The 'stem' of a multiple choice item is the part that asks the question or states the problem. If the stem is clear, it gives the student an idea of what is sought before reading the options.

(2). Make the options reasonable.

Discrimination among students is facilitated by ensuring that all options seem reasonable to someone who is unsure of the exact information.

(3). Make sure that unintentional clues are not provided.

Sometimes a student can eliminate an option because it is grammatically incorrect.

(4). Check the format.

Skip a line between stem and choices to make it easier for the students to visually separate these components. Keep entire questions (stem and choices) together as a single page.

4. Test Length and Duration.

There is no readymade formula that can be used to determine the minimum number of items that should be used for the test to be valid. It can vary according to its purpose. Since the test was used for testing the various
levels of cognition of thirty-two concepts, it required more items. The test has two parts (Part I and Part II) containing sixty items and fifty items in each part.

Table 4.5
Blueprint of Part I of the Achievement Test.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Elements of a set</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Cardinality</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Finite sets</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Infinite sets</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Singleton set</td>
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<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Doubleton set</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Null set</td>
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<td>0</td>
<td>2</td>
<td>4</td>
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<tr>
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<td>1</td>
<td>1</td>
<td>4</td>
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<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
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<td>1</td>
<td>1</td>
<td>4</td>
</tr>
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<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Identical sets</td>
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<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Disjoint sets</td>
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<td>1</td>
<td>1</td>
<td>3</td>
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<td>Intersection of sets</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
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<td>Compliment of set</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Difference of sets</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
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<td>16</td>
<td>14</td>
<td>13</td>
<td>60</td>
</tr>
</tbody>
</table>
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Table 4.6
Blueprint of Part II of the Achievement Test

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phrase</td>
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<tr>
<td>Sentence</td>
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<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Algebraic phrase</td>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Numerical phrase</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Numerical sentence</td>
<td>0</td>
<td>2</td>
<td>0</td>
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<td>4</td>
</tr>
<tr>
<td>Algebraic sentence</td>
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<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
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<td>Closed sentence</td>
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<td>0</td>
<td>1</td>
<td>3</td>
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<td>1</td>
<td>3</td>
</tr>
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<td>Always true</td>
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<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
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<td>sentence</td>
<td>Identity</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
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<td>Domain</td>
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<td>2</td>
<td>1</td>
<td>5</td>
</tr>
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<td>Truth set</td>
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<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Simple Equations</td>
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<td>1</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Equivalent Equations</td>
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<td>1</td>
<td>1</td>
<td>4</td>
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<tr>
<td>Total</td>
<td>11</td>
<td>17</td>
<td>12</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

5. Construction of Test Items.

A draft question paper consisting of hundred multiple-choice items for part I and eighty multiple-choice items for part II was prepared. Majority of the items was intended for average students, but neither the intelligent nor the dull was ignored. Items written were given to experts for getting their suggestions for improvement. The modifications were made accordingly.
Items were arranged according to their expected level of difficulty; the easiest questions were included in the beginning for motivating the students. The draft form was printed in the form of a booklet.

Necessary directions were printed on the first page of the booklet. Separate answer sheets were printed. One hundred copies of the question papers and answer sheets were printed for try out. A copy of draft test - Part I and Part II is given as Appendix B and C.

6. Tryout.

For standardisation, item analysis has to be done. For this the test should be first given to a small group representing the whole population. This process is called try out. Pilot test was administered to a sample of 100 eighth standard students selected by stratified random sampling procedures from the three schools in Pathanamthitta district.

The table shows the details of the schools and the sample selected for tryout.

Table 4.7

<table>
<thead>
<tr>
<th>Schools and Sample Selected for Try-out.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of School</strong></td>
<td><strong>Boys/Girls</strong></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>P.G.M.G.H.S, Parakode</td>
<td>Girls</td>
</tr>
<tr>
<td>P.G.M.B.H.S, Parakode</td>
<td>Boys</td>
</tr>
<tr>
<td>Govt.H.S, Maroor</td>
<td>Boys &amp; Girls</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Enough time was given to the students to complete the test. Separate answer sheets were printed for answering the test. The scoring was done by giving one point credit for each correct response and zero point for each wrong response. Sample answer sheets with key for Part I and Part II is given as Appendix D and E.

7. Item Analysis.

Item Analysis is the process of establishing the suitability of an item for inclusion in the final test. The quality of each item is ascertained by analysing two important characteristics of the item i.e., (1) difficulty index and (2) discriminating power.

Kelley’s method (Kelley, 1939) was used to calculate the difficulty index and discriminating power. Based on the scores obtained pupils were arranged in descending order of magnitude i.e. from highest to lowest. Then the first 27% (27 nos) and last 27% (27 nos) of paper were used for item analysis. The difficulty index and discriminating power were calculated using the formula

Difficulty index \( Di = \frac{(U+L)}{2N} \) and

Discriminating power \( Dp = \frac{(U-L)}{N} \)

Where \( U \) - the number of pupils in the upper group who made correct response

\( L \) - the number of pupils in the lower group who made correct response

and

\( N \) - the number of pupils in each group.
The items for the final test were selected according to the steps supported by Garrett (1973). According to him: "As a general rule items with difficulty index of 0.2 or more are regarded as satisfactory. 

Items having difficulty index between 0.3 and 0.7, discriminating power above 0.4 for Part I, and items having difficulty index greater than 0.3 and less than 0.75, discriminating power greater than or equal to 0.35 for Part II were selected for the final test.

The details regarding the difficulty index and discriminating power of each item—Part I and Part II of the achievement test are given in the Appendix F and G.

(i) Distractor Analysis

The test consists of multiple-choice items only. Hence there is a chance of guessing the answers. If the distractors were properly given, guessing can be eliminated. So, the distractor analysis was done to eliminate defective distractors.

8. Preparation of the Final Test.

Out of the 100 items for Part I and 80 items for Part II included in the tryout, 60 items from Part I and 50 items from Part II were selected for the final test based on the difficulty index and discriminating power of items. The final format of the test contains 60 items in Part I and 50 items in Part II. Frisbe (1971) has suggested that multiple-choice item having four/five responses can be responded in about seventy-five seconds. As per Frisbe's (1971) suggestion and the time taken by the students in the preliminary try out, the time duration
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of the final test was fixed as fifty minutes for Part I and forty minutes for Part II. The final test was also printed in booklet form with all necessary instructions. Separate answer sheets were printed for answering test. A sample achievement test - Part I and Part II are given as Appendix H and I. Sample answer sheet with key of the achievement test - Part I and Part II are given as Appendix J and K.


a). Reliability of Achievement Test.

After completing item analysis, arranging the test item in systematic order and deciding the time duration, reliability of the test was established through split-half method. Next to validity, reliability is the most important characteristic of assessment results. Reliability provides the consistency that makes validity possible and indicates the degree to which various kinds of generalisations are justifiable.

In determining the reliability it would be desirable to obtain two sets of measure under identical conditions and then to compare results. As a substitute for this ideal procedure, several methods of estimating reliability have been introduced (American Association, 1985).

The split-half method is easy to implement with a traditional test with 10 or more items. To split the test into two halves that are equivalent, score the even and odd items separately. The total score for each student on each half should be determined and the correlation between the two total scores for both the halves is computed.
This method has the advantage that only one test administration is required and therefore memory or practice effects are not involved and furthermore it does not require two tests. The reliability coefficient of the whole test can be calculated using Spearman Brown Prophecy formula \( R = \frac{2r}{1+r} \) where \( R \) is the reliability coefficient of the whole test and \( r \) is the coefficient of correlation between the half tests. The value of coefficient of correlation between the half tests was 0.889 and the reliability coefficient of the whole test was calculated as 0.941. Hence the test is reliable.

**b). Validity of the achievement Test.**

Validity refers to the adequacy and appropriateness of the interpretations made from assessments, with regard to a particular use. Validity is always concerned with a specific use of assessment results and the soundness of our proposed interpretations of those results. As far as an achievement test is concerned, content validity and empirical or statistical validity are important.

1. **Content Validity.**

According to Lindquist (1951) "the content of an achievement test is often formulated by analysis of curriculum and text and pooled by judgement of recognised authorities in the field. Such test may be described as self defining". Since the test was constructed keeping in view of the weightage of different concepts on the one hand and expert's comments on the other, it was treated as a valid test. In other words, in the preparation of the present test, the procedure
Methodology

adopted for constructing the test provides evidence regarding the content validity of the test.

2. Concept or Construct Validity.

In this study, the concepts are selected from the topics 'Sets', 'Expansion of Algebraic Expression using Identities', and 'Simple Equations'. The investigator organised the concepts in logical order and gave adequate representation in the achievement test prepared.

The sentence styles varied in variety and also in length. Effective use of words was made by selecting the precise meaning and variety. Easily readable and comprehensible sentences were used in all questions. Thus the Achievement test prepared by the investigator fulfilled the requirements for effective expression. Hence the test has good construct or concept validity.

3. Empirical or Statistical Validity.

The product-moment coefficient of correlation was calculated using the achievement test scores (prepared by the investigator) and the marks obtained for mathematics in the first terminal examination conducted in the school. The correlation coefficient obtained was 0.827. The obtained value shows that the test has good empirical validity.

c). Objectivity.

The objectivity of a test affects both the validity and reliability of it. In the prepared achievement test, objectivity is ensured by including only objective type items. Objectivity was also ensured by using scoring key for valuation.
d). Practicability.

Practicability of a test is a function of the ease of administration, readiness of interpretation, economy in initial cost, possibility in reusing materials time required for scoring and analysing the results. The prepared achievement test is easy to administer as it is in the booklet form. It is economical, as it is reusable, since the answer sheets are provided separately. Time needed for scoring is minimum as the window stencil method is adopted. Hence the test has good practicability.

4.2.3. Cognitive Ability Test.

Cognition refers to knowing and thinking. It involves taking in, storing, retrieving, transforming and manipulating information that is obtained through senses. Also it involves perception, awareness, judgement, the understanding of emotions, memory and learning. Flawell, et al. (1970) introduced the concept of Metamemory, which is one’s awareness of how one thinks. That is metamemory describes what one knows about how one remembers information.

Over the years, the term metacognition has become more commonly used than metamemory. Brown, et al. (1983) suggested that metacognition requires not only an awareness of cognition (i.e., an understanding of the information processing involved in complex skills) but also competence in planning, monitoring, self questioning and self directing.

Cognition and metacognition are fundamental to learning, problem solving and intelligent behaviour. Human cognitive performance is also closely
linked to intelligence. Cognition is not simply attention, coding, memory, metacognition or planning but a fusion of all brain activities.

Many assessment devices deal with behaviour within a single cognitive domain. Since 1970, test designs have begun to construct test batteries that measure behaviour across several domains called diagnostic systems. These comprehensive instruments help the tests to link performance in one domain with performance in other.

Luria (1973) proposed that each area of human brain concerned with a functional system introduce its own particular factor, which is essential for normal, correct performance.

Based on Luria’s approach, Das, et al. (1975) developed an information integration model which operationalised Luria’s functional organisation of the brain in information processing terms. A refinement of original model is known as the PASS theory of intelligence referring to Planning, Attention, Simultaneous and Successive.

Stimuli (input) are accepted through any receptor (sense or variety of internal organs) as a complete unit or as part of a sequence. Das, et al. (1994) referred to these methods of presentation as simultaneous and successive respectively. Stimuli pass to the central processor which comprises three components; a unit which mediates arousal and attention; one that mediates the encoding and decoding process; or the simultaneous and successive dimensions and a third component that operates to make and enact plans and make
decisions. Information then passes from central processor as thoughts or actions depending upon cognitive task being attempted in either simultaneous or successive form.

Kaufman Assessment Battery for Children (Kaufman and Kaufman, 1983) is a battery of tests that assesses student's performance on the two coding processes identified by Luria (1966) – simultaneous and successive processing and achievement. Sequential processing deals with stimuli in a serial or temporal fashion, and simultaneous processing is concerned with information presented as a whole unit.

The main subtests in the Kaufman Assessment Battery for Children (K-ABC) includes sequential processing scale, simultaneous processing scale and achievement scale. There are subtests in each of these categories.

Das-Naglieri Cognitive Assessment System (DN.CAS) provides a broad view of children's information processing capabilities by covering four cognitive domains: planning, attention, simultaneous processing and successive processing.

One objective of the Das-Naglieri Cognitive Assessment System is to provide information about the cognitive characteristics of children using the dimensions identified by Luria (1966), namely planning, arousal, simultaneous and successive planning. This information together with other test data could be used for making decisions about diagnosis and instructional programming.

According to Vygotsky (1978) education should be designed to accelerate children's cognitive development, rather than providing experience at
individual's current level of cognitive maturity. Children must comprehend meaning and integrate the knowledge into their own thinking. How one learns about world is influenced by one's 'readiness' to learn and how one is taught. Vygotsky developed the concept of Zones of Proximal Development to express the potential of the individual to learn.

Vygotsky (1978) referred ZPD as the 'distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers'. This theory influenced the assessment procedure that targeted student's cognitive characteristics.

Instrumental Enrichment (I.E) was developed by Feuerstein and his colleagues in Israel (Feuerstein, et al, 1980). This clearly fits within the assessment, preparation, instruction and evaluation.

Haywood (1992) describes this as a conceptually rich imaginatively operationalised programme which is designed to stimulate the acquisition of cognitive processes so that student's perception, learning, thinking and problem solving are enhanced across a wide range of cognitive activities. It is based on a series of fifteen instruments of increasing complexity each designed to develop thinking process using paper and pencil exercises. They are described below.
a) **Organisation of Dots.**

Identification and outlining of geometrical figures from a cloud of dots to show a set of overlapping geometric shapes (e.g. squares, triangles etc).

b) **Orientations in space II, III, and I.**

This deals with spatial orientation relative to one’s own body. The task is to represent the relationship between fixed objects and a humane figure, which changes its orientation.

c) **Comparisons.**

This involves the forced comparisons of two objects on dimensions such as size, form, number, spatial components, temporal components, as well as abstract components not immediately perceived.

d) **Categorisation.**

In this the child has to label, compare, discriminate and combine objects according to specific classification, but then these same objects may be regrouped according to a different set of criteria.

e) **Analytic Perception.**

This involves looking at an object in terms of its component parts to identify the relationships between parts. Figures have to be completed, specific shapes identified, and patterns matched with their component parts.
f) **Family Relations.**

This is to recognise relationships and the multiple roles (and their attributes) of each person (e.g. grandfather, father, brother). This task uses verbal, symbolic and graphic modalities of presentation.

g) **Temporal Relations.**

These are problem solving activities requiring the collection of relevant information such as starting points, routes, time and average speed, and combining those so that multiple factors are dealt with simultaneously.

h) **Numerical Progressions.**

In this, child has to be developing a sequence (usually numerical) which establishes a relationship between two events, the pattern by which the relationship repeats itself, and the discovery and formulation of the rule, which generates the pattern.

i) **Instructions.**

This requires the child to read an instruction and act on it using a systematic and ordered approach. The child is required to gather data, order the object in the desired relationship, and carry out the instructions.

j) **Illustrations.**

A series of pictures show a progression of events where the child must be perceive a problem, recognise what is happening in the situation and search for a solution by generating comparisons and relationships.
k) **Representational Stencil Design.**

This requires the mental construction of a design. The child copies, colours, and cut-out stencils printed on a sheet by specifying which stencils must be used and in which order they must mentally superimpose on each other to recreate the desired pattern.

l) **Transitive Relations.**

In these the child has to seek new relationships from those existing between objects and/or events by using terms greater than, equal to or less than.

m) **Syllogisms.**

These deal with formal propositional logic by expanding the concept of sets. The child learns about the laws governing sets and their members, their implication of these laws and the construction of new sets by various operations such as logical multiplication.

Instrumental Enrichment (I.E) is based on Vygotskian concept of mediated learning. It has been suggested that mediated learning experiences are fundamental for cognitive development and may overcome some socio-cultural deficits that can affect intellectual development such as poverty, emotional disturbance, and poor educational opportunities (Haywood 1993). Also Feuerstein, et al. (1980) acknowledged that the amount of mediated learning that each student requires would vary according to the degree of socio-cultural deprivation.
The investigator constructed a Cognitive Ability Test based on the above described theories and Cognitive Assessment Tests. The draft form of the test contains forty-five items under different categories.

1. **Construction of Items.**

   *(i). Organisation of Dots.*

   In this the child has to identify square and triangle and outline it from a cloud of dots. Item number 1 and 7 of the draft form of cognitive Ability Test are based on this category.

   *(ii). Logical Venn – Diagram.*

   This deals with questions, which aim at analysing the student's ability to relate certain given group of items and illustrate it diagrammatically. Item numbers 3, 4, 5 and 6 of the draft form of cognitive Ability Test are from this category.

   *(iii). Categorisation. (Grouping of Identical Figures).*

   The student has to compare and combine objects according to specific classification. The child is required to analyse the objects and classify them into groups consisting of objects/figures having more or less the same properties. In the draft form of cognitive Ability Test, the item number 2 is based on this theory.

   *(iv). Analytical Reasoning.*

   This involves problems relating to the counting of geometrical figures in a given complex figure. The systematic method for determining the number of any
particular type of figure by the analysis of complex figure. In the draft form of cognitive Ability Test, the item number 8 and 9 are based on analytical reasoning.

(v). **Arithmetical Reasoning.**

This includes different types of items. They are Venn diagram based items, calculation based items and data based items. Here the child has to analyse these problems within the given data or framework and arrive at conclusion by logical reasoning. The investigator prepared items on calculation based and Venn diagram based. In the draft form of Cognitive Ability Test, item number 10 and 13 are from Venn diagram based items and item number 44 and 45 are from calculation based items.

(vi). **Mirror Images.**

A mirror image is the image of an object as seen in a mirror. In the mirror image of an object, the right side appears on the left side and vice-versa. A mirror image is said to be laterally inverted. Item numbers 11, 12, 14 and 15 of the draft form of Cognitive Ability Test are dealing with this.

(vii). **Analytic Perception.**

This involves looking at an object in terms of its component parts. Figures have to completed, specific shapes identified, and patterns matched with their component parts. These are brain teasing problems with construction of figures by combination of the parts selecting from the list of given alternatives. Items 16, 17, 18, and 23 of the draft form of Cognitive Ability Test are from this category.
(viii). Analogy – Completing the analogous pairs.

Analogy means correspondence. In these types of equations a particular relationship is given and another similar relationship has to be identified from the alternatives provided. Here, in the Cognitive Ability Test two words are given. Those words are related to each other in some way. The child is required to find out the relationship between the first two words and choose the words from the given alternatives which leaves the same relationship to the third word, as the first two bear. In the draft form of Cognitive Ability Test, item number 19, 20, 21, and 22 are from this category.

(ix). Series Completion.

In this the child learns to develop a sequence which establishes a relationship between two events. This section deals with questions in which series of numbers or alphabetical letters are given, which are generally called as terms of the series. These terms follow certain pattern throughout. The child is required to recognise this pattern and complete the given series with most suitable alternatives. The series may either be number or letter series. Items 24, 25, 27 are based on number series and 26 and 28 of the draft form of Cognitive Ability Test, are based on letter series category.

(x). Following Instructions.

In this type of items the student is required to read an instruction and act on it using a systematic and ordered approach. The child has to gather data,
order the object in the desired relationship and carry out the instruction. In the draft form of Cognitive Ability Test, items 29 and 30 are based on this category.

**(x) Orientation in Space.**

This deals with spatial orientation. Some clues regarding seating or placing sequences (linear or circular) of some persons or things are given. The child is required to form the proper sequence using these clues and find the solution accordingly. Item numbers 31, 32, 41 and 42 of the draft form of Cognitive Ability Test are from this category.

Another types of tasks are used for testing the direction sense of the child. It involves the testing of the knowledge of the concepts left, right, front, back, beneath, beside, east, west, north, south. Item numbers 37 and 39 of the draft form of Cognitive Ability Test are of this category.

**(xii) Family Relationship.**

These are items to test the knowledge of kinship and family relations through verbal, symbolic and graphic modalities of presentation. In this the success of the student depends upon the knowledge of blood relations. In the draft form of Cognitive Ability Test, items 35 and 36 are from this category.

**(xiii) Ranking.**

Generally the ranks of a person both from top and from the bottom are mentioned and the total number of persons is asked. Sometimes the question is put in the form of a puzzle of interchanging sets by two persons. Item numbers 38 and 43 of the draft form of Cognitive Ability Test are from this category.
Comparison Type.

In this type of questions clues are given regarding comparison among a set of persons or things with respect to one or more qualities. The student is required to analyse the whole information from a proper ascending/descending sequences and then answer the items accordingly. Item numbers 33 and 34 of the draft form of Cognitive Ability Test are based on this.

Syllogism.

The items in this section consist of a statement/group of statements followed by certain inference based on the facts contained in the given statements. The student is required to analyse the given statements, understand their indirect implications and then decide which of the given conclusions follow logically and sure from the given statements. In the draft form of Cognitive Ability Test, item number 40 is of this type.

The draft test consists of 45 multiple choice items from the above sections. Multiple choice questions have an advantage of providing highly standardised testing and making procedure. The draft was given to experts for getting their suggestions for improvement. The modifications were made accordingly. Separate answer sheet was also provided. A copy of draft test is given in the Appendix L. Sample answer sheet with key of the draft form of the test is given in the Appendix M.
2. **Tryout.**

The pilot test was administered to a sample of 100 VIIIth standard students selected from three schools. The Table 4.8 shows the details of the sample selected for tryout.

Table 4.8.

<table>
<thead>
<tr>
<th>Name of school</th>
<th>Boys /Girls</th>
<th>Rural/Urban</th>
<th>Govt/Pvt</th>
<th>No of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.G.M.G.H.S, Parakode</td>
<td>Girls</td>
<td>Urban</td>
<td>Pvt.</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Boys &amp; Girls</td>
<td>Rural</td>
<td>Govt.</td>
<td>30</td>
</tr>
</tbody>
</table>

The scoring was done by giving one point credit for each correct answer and zero point to each wrong answer.

3. **Item Analysis.**

Item analysis can be done qualitatively in terms of their content and form, and quantitatively in terms of their statistical procedures. Qualitative analysis includes the consideration of content validity and evaluation of items in terms of effective item writing procedures. Quantitative analysis includes the measurement of item difficulty and item discrimination.

Kelly’s (1939) method was used to evaluate the difficulty index and discriminating power. The group is divided into two subgroups (above and below average) and their performance was compared.
Methodology

Difficulty index $D_i = \frac{(U + L)}{2N}$ and
Discriminating index $D_p = \frac{(U - L)}{N}$.

Where $U =$ Number of pupils in the upper group who made correct response.
$L =$ Number of pupils in the lower group who made correct response and
$N =$ the number of pupils in the each group.

According to Garret (1973), items with difficulty index 0.2 and above are regarded as satisfactory. Fraser and Gillam (1972) suggest that the value of discriminating power should not fall below 0.3. Items having difficulty index between 0.35 and 0.75 and discriminating power greater than or equal to 0.35 are selected for the final test. The details regarding the difficulty index and discriminating power of each item and given in Appendix N.

(i) **Distractor Analysis.**

The distractors were prepared in such a way that each of the distractors appears to be a reasonable answer. The most reliable tests are constructed of distractors with similar characteristics. So the Distractor analysis was done to eliminate defective distractors.

4. **Preparation of final test.**

Thirty items were selected for the final test based on the difficulty index and discriminating power of items. For pilot testing liberal time was allowed to each student. The average time required by the students was taken. According to Frisbe (1971) the time required for responding a four/ five response multiple choice item is about 75 seconds. The time of the final test was fixed as 35 minutes by considering the above matters. Necessary instructions were given in
the booklet form and separate answer sheets were also given. Sample of the final form of the Cognitive Ability Test, and its answer sheet with key are given in the Appendix O and P.

5. **Reliability of the test.**

The reliability of a test means the extent to which it is dependable. The test was carried out just once and split into two equal halves, often by odd-even items, and then correlated the result to establish the split-half reliability. Carefully constructed cognitive tests would be expected to have coefficients above 0.9. Reliability coefficient of 0.65 and higher is considered as reliable. Here the split-half reliability coefficient of the test was 0.9088. Hence the test is reliable.

6. **Validity of the test.**

A test is valid if it measures what it supposed to measure. Content validity refers to the adequacy with which the test items represent the conceptual domains of interest. It examines whether the test includes all of the important aspects of the target that we wish to measure and whether the various aspects are properly weighed. Asking people who are knowledgeable in the particular area can check this. This was done at the preparation stage of the test itself. Hence the test is having content validity.

A second form of validity is criterion validity. The issue in criterion validity is whether a participant's performance in the test to measure the attribute in question relates to some external criterion. Academic performance in the school
can be taken as a common criterion related to the ability to cognition. The marks scored by the students in the first terminal examination was collected. The coefficient of correlation between the two scores was calculated as 0.771. This shows that the test is valid.

The final form of validity is construct validity. According to Kerlinger (1986) it is not simply a question of validity of test. One must try to validate the theory behind the test.

According to the cognitive development stages explained by Piaget, the child's reasoning process becomes logical during concrete operational period. The items contained in the test come under sections like analogies, time and speed, seriation, etc., the processes which were explained by Piaget. Hence the test is having a good theoretical base.

According to Borich (1996), acceptable validity coefficient for a test generally ranges between 0.6 and 0.8 or higher, while acceptable reliability coefficients generally range from 0.8 to 0.9 or higher. Test accuracy deals with the question 'does the test approximate the individual's true level of knowledge, skill or ability?'. It is a combined mean of validity and reliability. Based on the obtained values of reliability coefficient and coefficient of correlation related to criterion validity, the test is valid and reliable and hence it is having test accuracy.
4.2.4 Rao Achievement Motivation Test.

1. Academic performance and Achievement Motivation

For a long time in the history of educational institutions, academic performance was conceived to be almost exclusively a function of intelligence and aptitude. However aptitude and intelligence tests have not been given perfect predictions. It is perceived to be much more complicated problem involving motivational factors as well as intelligence and academic skills (Heyns, 1958). Educationists and psychologists are unanimous in appreciating the importance of motivational factors in academic success. Achievement is capable of improvement by due consideration of factors other than native ability.

The concept of Achievement Motivation refers to the need of an individual to perform according to a high standard of excellence. It has been measured by and large, in two ways, projective techniques and paper pencil questionnaire.

Rao Achievement Motivation Test has been developed to provide a simple and objective measure of Achievement Motivation of secondary school pupils. The investigator used Rao Achievement Motivation Test for finding out the Achievement Motivation of students in the sample of the present study.

In the test, there are twenty incomplete sentences, each of which is followed by two possible alternatives A and B out of which one is an achievement-related item. Though both the alternatives are achievement oriented and socially acceptable, yet one of them implies a higher sense of
achievement and excellence. The student has to indicate the alternative he generally prefers. The test may be administered to a group or an individual. There is no time limit but the group test takes about 8-10 minutes. The high achievement related statements were given a score of 3 and low achievement related statements were given a score of 1. A sample of the test is given in the Appendix Q.

2. Reliability & Validity.

The coefficient of reliability was found to be 0.79. In the process of Item Analysis only those items which had a discriminating index of 0.25 and above were included in the final test. Also there was agreement between the judgement of teachers and the score on the Achievement Motivation Test. Hence the test is reliable and valid.

4.2.5. Measurement of Socio-economic Status.

It is assumed that education, occupation and income are the three essential variables which determine the socio-economic status of modern society. The investigator used adapted version of Kuppuswamy’s (1962) Socio-economic Status scale published by Manasayan, for finding out the socio-economic status of students in the sample of the present study. The scale used by the investigator is an adapted version by modifying according to the pay scales existing at the time of administration of the tool. Here the socio-economic status of a student is measured in terms of three variables, education, occupation and income of
parents. The modified version containing the three variables with classifications is presented in Table 4.9.

Table: 4.9.

Weightage Given to the Items in the Socio – Economic Status Scale.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Education</th>
<th>Weightage</th>
<th>Occupation</th>
<th>Weightage</th>
<th>Income per month Rs</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Masters degree, professional degree and above</td>
<td>10</td>
<td>High professional</td>
<td>10</td>
<td>Above 8000</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Bachelors degree</td>
<td>8</td>
<td>Semi-professional</td>
<td>8</td>
<td>4351 - 8000</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Pre-degree Pre-University SSLC</td>
<td>5</td>
<td>Skilled workers</td>
<td>7</td>
<td>3451 - 4350</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Up to Standard 7</td>
<td>4</td>
<td>Semiskilled workers</td>
<td>4</td>
<td>2601 - 3450</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Literate (completed lower primary) Illiterate</td>
<td>1</td>
<td>Unemployed</td>
<td>0</td>
<td>Below 1750</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Literate (completed lower primary) Illiterate</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


The validity of the scale was determined by matching the socio-economic scores of well-known people with the estimate of their social class made by teachers about these people and by comparing dichotomous groups on their means. The highly significant mean differences showed the good discriminating power of the scale.
Full weightage is given to the head of the family/father/mother. Half credit is given to the other parent. If the elder sister/brother’s education, occupation or income is higher than that of parent’s, one point weightage is given and a maximum of two points if both the sister and brother are higher in education, occupation or income. If the sister or brother is unmarried or staying with the family after marriage, a one point weightage is given.

The total score obtained for the three dimensions of socio-economic status designed above yielded a composite score for each member. The sum of the composite score obtained for all the members in the family was taken as the socio-economic status of the family. A sample of the Socio-economic Status scale is given in the Appendix R.

4.2.6. Self-Concept Inventory.

Self concept is individual’s perception of himself as a person, it includes his abilities, appearance, performance in his job/study and other phases of daily living. Self-concept is a dominant event in personality pattern. A variety of methods and techniques have been developed to measure self-concept.

Rogers (1951) defined self-concept as “An organised configuration of perceptions of the self which are admissible to awareness. It is comprised of such elements as the perceptions of one’s characteristics and abilities, the percepts and concepts the self in relation to others and to the environment, the value qualities which are perceived as associated with experiences and objects, and the goals and ideals which are perceived as having positive or negative valence”.

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Methodology

According to Saraswat and Gave (1981), "the self concept is the individual's way of looking at himself. It also signifies his way of thinking, feeling and behaving".

The investigator used the Self-concept Inventory prepared by Dr. R.K. Saraswat and published by National Psychological Corporation, Kacherighat, Agra.

1. Description of self-concept inventory.

The self-concept Inventory provides six separate dimensions of self-concept viz. physical, social, intellectual, moral, educational and temperamental self-concept. It also gives a total self-concept score. Each dimension contains eight items. Altogether there are forty-eight items. Against each item there are five responses. Student has to read each item carefully and respond to it by putting a tick mark (✓) on any of the five responses given against them, which he thinks describe him well. There is no time limit but generally twenty minutes have been found sufficient for responding all the items.

2. Scoring.

The alternatives or responses of all items are arranged in such a way that the scoring system for all items will remain the same, i.e. 5, 4, 3, 2, 1, whether the items are positive or negative. The summated score of all the forty eight items provide the total self concept score of an individual.
3. **Reliability and Validity.**

Reliability of the test was found by test-retest method. Reliability coefficient of the test is 0.91. Expert's opinions were obtained to establish the validity of the inventory. Items of highest agreement and not less than 80% of agreement were selected. The content and construct validity was then established. A sample of the Inventory is given in the Appendix S.

### 4.2.7. Measurement of Study Habits.

For the present investigation, to measure the Study Habits of students, the investigator used the study habits inventory prepared by Dr. B.V. Patel and published by Agra Psychological Research Cell, Agra.

1. **Description of the Inventory.**

This inventory consists of 45 items. Each item was in the form of a statement. Each statement was scaled on a five-point scale and the five points are Always, Often, Sometimes, Hardly and Never. The items fall into the following seven areas (1) Home Environment and Planning of Work (2) Reading and Note Taking (3) Planning of Subject (4) Habits of Concentration (5) Preparation of Examination (6) General Habits and Attitudes (7) School Environment.

After reading each statement, the student has to put a tick mark (✓) in the proper column by deciding critically to what extent it resembles to his study habits at present. There is no time limit and they have to answer all items.
2. Scoring

Out of the 45 items, 27 items were depicting good study habits and the rest 18 items depicting bad study habits. In case of items depicting good study habits, the student is to give 5 marks if he puts a tick (✓) in the column of always; 4, 3, 2, and 1 are to be given if he puts tick mark in the column of often, sometimes, hardly and never respectively.

In the case of statement depicting bad study habits, the score is to be assigned in the reverse order.

3. Reliability and Validity.

The reliability was established by test-retest method and split half method. The reliability coefficient by test-retest method and split half method were found to be 0.79 and 0.82 respectively. Scores on the study habits inventory were correlated with teacher's opinion and examination marks. With teacher's opinion, the coefficient of correlation was 0.4 and with previous examination scores it was 0.5. A sample of the inventory is given in the Appendix T.


Interest in mathematics of an individual can be measured by measuring the interest of the individual in doing problems, studying mathematical theories, and identifying figures and shapes and in activities in which principles of mathematics involved. The investigator used the Interest Inventory prepared by
Mr. Prasanna Kumar, Department of Education, University of Kerala to measure the interest in mathematics of students in the sample.

1. **Description of the Interest Inventory.**

The present Mathematics Interest Inventory consists of 40 items. Each item contains three different statements. Each item is an appeal to the student to choose one alternative from the three alternatives given, supposing that equal facilities are provided to three alternatives in each item. Naturally one of the three choices is related to Mathematics and that particular choice scores a point one in each of these 40 items. The rest of the two alternatives given no points, the maximum score are 40 points.

2. **Reliability and Validity.**

The reliability of the Mathematics Interest Inventory was found by split half method. The reliability coefficient of the test was found to be 0.816. The teachers were requested to rate the pupils according to their mathematics interest on a five-point scale. Then using the rating and scores obtained by using Interest Inventory were correlated and it was found to be 0.49. A sample of the inventory is given in the Appendix U.

4.2.9. **Measuring Attitude for Mathematics.**

Attitudes are the predisposition or tendency to react specially toward an object, situation, or value, usually accompanied by feeling and emotion. Attitudes cannot be directly observed but must be inferred from overt behaviour. An individual’s attitude towards mathematics is an organisation of motives
around his responses to the subject Mathematics, its theories, applications and uses. Attitudes show an evaluative personal reaction.

The investigator used the Attitude Scale for Mathematics prepared by H.G. Desai of Department of Education, Saurashtra University, Rajkot for measuring the Attitudes towards mathematics of students in the sample.

1. Description of Attitude Scale.

The Attitude scale contains 20 items. Each item is in the form of statements. Of which 9 items are positive statements and 11 are negative statements. The statements are arranged on 3-point scale with the responses “Agree”, “Disagree”, and “No Opinion”. The student has to put a tick (✓) against each item in the respective column Weight 3, 2, 1 are assigned to Agree, Disagree, and No Opinion respectively for positive items and weights were reversed for negative items.

2. Reliability and Validity.

To establish the reliability of the test, Split-half method and test-retest method were used. The reliability coefficient for Split-half method and test-retest method were found to be 0.86 and 0.74 respectively. To establish the validity of the test, the test scores are validated against teacher’s ratings. The coefficient of correlation of the two was found to be 0.66. A sample of the Attitude Scale for Mathematics is given in Appendix V.
4.2.10. Measurement of Home Learning Environment

Home Learning Environment plays a significant role in the academic achievement of children. In motivating pupils for study the place of home and neighbourhood is very important.

The investigator used a Home Learning Environment Inventory for collecting necessary data regarding the student's Home Learning Environment for Mathematics. This is a modified form of the test developed by Nair, A.S. and Nirmaladevi (1981).

1. Description of Tool.

This was intended to find out the extent to which the parents and other significant members of the family provide facilities for the attainment of maximum learning. It consists of 40 items covering different aspects of home environment. The students were asked to respond to each item by putting a tick (✓) against the entries of a three point scale marked “Always”, “Sometime”, and “Never”.

The weightage assigned as 3, 2, and 1 for the responses “Always”, “Sometime”, and “Never” respectively, for each item. The score of the individual is the sum all scores obtained by him for all the 40 items in the inventory. The split half reliability coefficient of the original inventory was 0.69. The validation of the tool was done by correlating the scores of the inventory with the total class achievement of the 85 pupils of standard X in a selected
secondary school. The correlation obtained was 0.41. A sample of the inventory is given in the Appendix W.

### 4.2.11. Measurement of Intelligence

Intelligence tests are available in verbal and non-verbal forms. Verbal tests, on the whole, place a premium on the language ability of the individuals. Verbal tests may underestimate the intellectual capacity of children who speak a different dialect or for whom the language of the test is not their mother tongue. Thus children who have language difficulties or who come from another cultural background may be at a disadvantage when taking the test. Therefore verbal tests are of doubtful value when common measures of intelligence of pupils drawn from widely differing backgrounds are required. So the investigator decided to use a non-verbal test of intelligence for the present study.

There are individual and group tests of intelligence. While individual tests are mainly used in clinical settings for the diagnosis of learning difficulties, group tests are used largely for selection purposes in education. Correlation between individual and group tests is fairly high and it is felt that they are each measuring the same kinds of ability. For a study of present type, it is better to use a group test of intelligence because of its importance and obvious merits over the individual test of intelligence. Hence it was decided to use a non-verbal group test of intelligence for the measurement of intelligence.
By considering the qualities of a good group intelligence test, the investigator decided to use Raven's Progressive Matrices sets A, B, C, D, and E for measuring intelligence of students in the sample of present study.

**Raven's Progressive Matrices sets A, B, C, D & E**

The test was intentionally chosen as an easy test to measure the cognitive functioning of the students. The standard Progressive Matrices (sets A, B, C, D & E) is a test of a person's capacity at the time of test to apprehend meaningless figures presented for his observation, see the relations between them, conceive the nature of the figure completing each system of relations presented and by doing so, develop a systematic method of reasoning.

Raven's Progressive Matrices (sets A, B, C, D & E) is a test for adults and children which requires testees to complete matrices in which every square, but one, has been filled in according to a certain pattern. When the testee has worked out the principle, he or she can then select the missing part of the design from a number of possible alternatives. Raven designed the test as a measure of Spearman's 'g' factor, that is, the ability to understand relations among abstract items.

The test consists of sixty problems divided into five sets of twelve. In each set first problem is self-evident. The problems which follows become progressively more difficult. The five sets provide five opportunities for grasping the method and five progressive assessments of a person's capacity for intellectual activity. As the five sets of items forming the scale each begin with
easy problems and end with difficult ones, the scores obtained will not be reliable, if the scale is used with a single time limit which does not enable everyone to finish.

The problems are in the form of patterns, with a bit missing. A number of alternatives (six for first two sets A and B and eight for the last three sets C, D, E) are given from which the correct answer has to be chosen. All of them appear to be correct, but there is only one correct answer, the child has to choose correct answer and put an 'X' mark in the box provided against each problem in the answer sheet separately given to them.

Everyone, whatever his age, is given exactly the same series of problems in the same order and is asked to work at his own speed, without interruption from the beginning to the end of the test. A person's total score provides an idea of his intellectual capacity whatever his nationality or education.

In a study on the effect of timing on predictability on Raven's test scores, Thampuratti (1969) arrived at the conclusion that twenty minutes seem to be the most satisfactory time span to complete the test, for the purposes of prediction of intelligence of pupil at the secondary level. From the original studies on SPM, Raven (1948), Foulds and Raven (1948) found reliabilities ranging from 0.83 to 0.93, with the higher values being associated with younger subjects, SPM correlates 0.86 with the Terman-Merrill scale and has been found to have a 'g' saturation of 0.82.
Methodology

The test is a popular measure used in Indian Schools. Nair (1967) in a study on selected sample in Kerala, found that the split-half reliability varied from 0.79 to 0.86 while the test-retest reliability varied from 0.89 to 0.91.

4.3 Sample of the Study.

For the experimental design adopted for the study, experimental and control groups were selected from eighth standard students of four schools, which follow Kerala State syllabus. The population under the study is academically disadvantaged students in 8th standard from the schools following Kerala State syllabus.

The investigator identified the academically disadvantaged students from eighth standard on the basis of the characteristics and factors sorted out from the studies reviewed in Chapter III. To identify them, the investigator prepared an ‘Index’ representing academic disadvantage of a student. For that the investigator took into account of the variables such as Cognitive Ability, Home Learning Environment, Mathematics Interest, Achievement Motivation, Self-concept, Attitude towards Mathematics and Study Habits.

The scores of Cognitive Ability, Home Learning Environment, Mathematics Interest, Achievement Motivation, Self-concept, Attitude towards Mathematics and Study Habits were calculated and converted into percentages. According to opinion of experts and from literature survey, The Academic Disadvantage Index (ADI) was calculated by giving appropriate weightage to the above percentages as follows.
Academic Disadvantage Index (ADI) = 0.5 X_1 + 0.1(X_2 + X_3 + X_4 + X_5 + X_6 + X_7)

Where,
X_1 = percentage of score on cognitive ability
X_2 = percentage of score on home learning environment
X_3 = percentage of score on mathematics interest
X_4 = percentage of score on achievement motivation
X_5 = percentage of score on self-concept
X_6 = percentage of score on attitude towards mathematics and
X_7 = percentage of score on study habits.

After calculating this Index, by applying the principle of the operation "Central Tendency Splits" the academically disadvantaged students were identified. Students whose ADI (Academic Disadvantage Index) is above 55.5862 were considered as academically advantaged and those who are having index less than or equal to 55.5862 were considered as academically disadvantaged.

4.3.3. Distribution of the Sample.

The sample consists of two groups - experimental group and control group. The total number of eighth standard students included in the study was 505 of which 268 were in experimental group and 237 in control group. Both the experimental and control group included academically advantaged as well as academically disadvantaged students.
4.4 **The Experiment Conducted.**

The present study is aimed at finding the effectiveness of concept attainment model of instruction (CAM) over the conventional teacher-centred approach (CTM) in mathematics teaching. The details of procedure adopted for the experiment are as follows.

*The main objective of this experiment was to collect data pertaining to the effectiveness of concept attainment model of instruction and the conventional method of teaching. The experiment conducted was on the intact unequated classroom groups selected from schools, which followed the Kerala State syllabus.*

*The experimental and control groups were pretested with the achievement test prepared by the investigator.*
### Table 4.11
**Detailed Distribution of the Sample Selected**

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Institution</th>
<th>Experimental group</th>
<th>Control Group</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Educationally Advantaged</td>
<td>Educationally Disadvantaged</td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>Govt: Vocational Higher secondary School, Nattalam</td>
<td>26</td>
<td>38</td>
<td>64</td>
</tr>
<tr>
<td>2</td>
<td>C.M.S High School, Pallom</td>
<td>21</td>
<td>27</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>P.G.M. Boys High School, Parakode, Adoor</td>
<td>42</td>
<td>30</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>P.G.M. Girls High School, Parakode, Adoor</td>
<td>56</td>
<td>28</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>145</td>
<td>123</td>
<td>268</td>
</tr>
</tbody>
</table>
The experimental and control groups were taught during the usual period assigned for Mathematics teaching in the school schedule. The experimental group was taught through the Concept Attainment Model of instruction. The control group was taught the same topics based on the conventional method of teaching. Experimental and control groups were tested using the achievement test prepared by the investigator (posttest).

4.5. Statistical Methods Adopted.

The pretest and posttest scores of the experimental and control groups were consolidated for statistical analysis. Since the aim of the investigator was to test the effectiveness of Concept Attainment Model of instruction on achievement in mathematics of academically disadvantaged students it was necessary to find out whether there is any significant difference between the mean scores of the two (experimental and control) groups.

Since the groups were intact unequated, the statistical technique ANCOVA was used for both the achievement scores and cognitive ability scores.

Multiple Regression Analysis was done to find out whether the mathematics achievement test scores and cognitive ability test scores of the academically disadvantaged students were influenced by the variables socio-economic status and intelligence.
References:


